



WHAT IS RESPONSIBLE FOR THE LOW-LEVEL MOIST PRECONDITIONING OF THE MJO?

Baijun Tian

Joint Institute for Regional Earth System Science and Engineering (JIFRESSE)
University of California, Los Angeles (UCLA)

Jet Propulsion Laboratory (JPL), California Institute of Technology (Caltech)

Tian, B. J., D. E. Waliser, X. Xie, W. T. Liu, and E. J. Fetzer, 2008, On the low-level moist preconditioning of the Madden-Julian Oscillation, *Geophys. Res. Lett.*, In Preparation.

AIRS Science Team Meeting, April 2008, Pasadena, CA

MADDEN-JULIAN OSCILLATION (A.K.A. INTRASEASONAL OSCILLATION)

✠ The MJO is characterized by slow eastward-propagating oscillations in tropical deep convection and large-scale circulation.

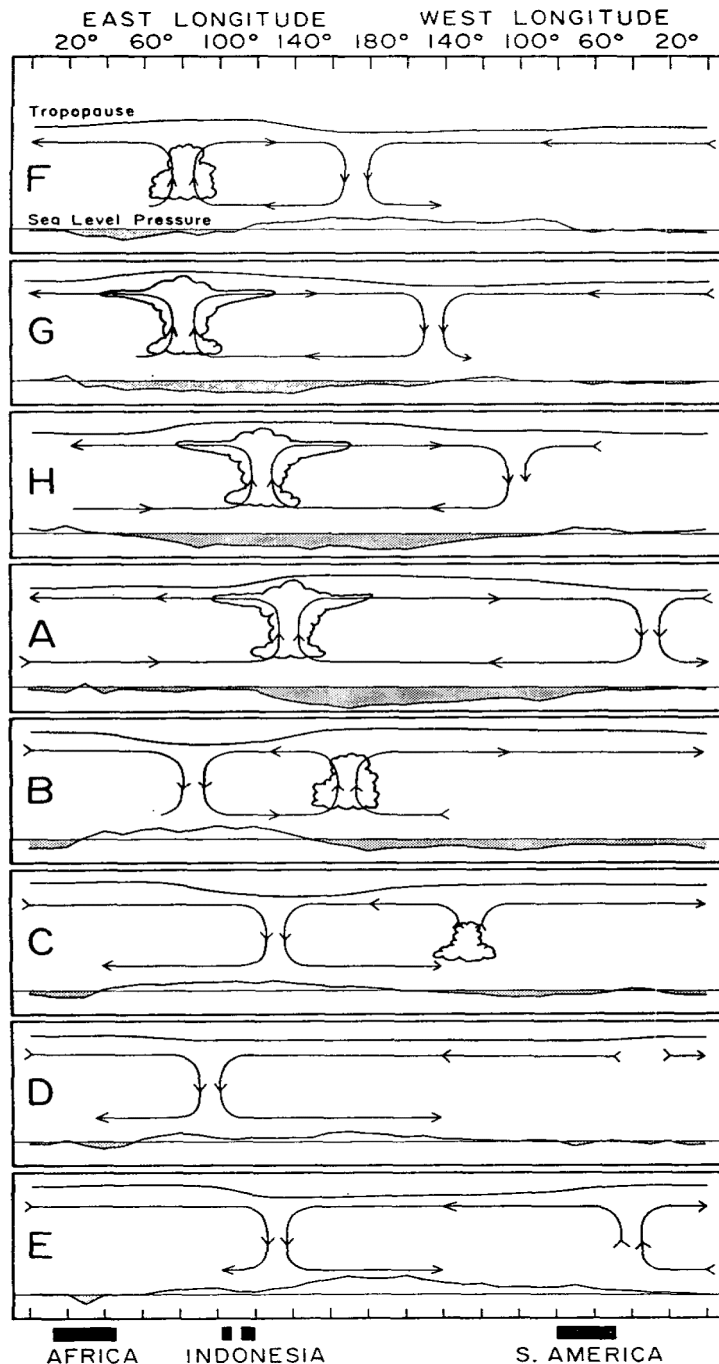
✠ It is the dominant form of intraseasonal variability in the Tropics.

✠ It impacts a wide range of phenomena (e.g., physical, biological and chemical components of the climate system).

✠ Our weather & climate models have a relatively poor representation.

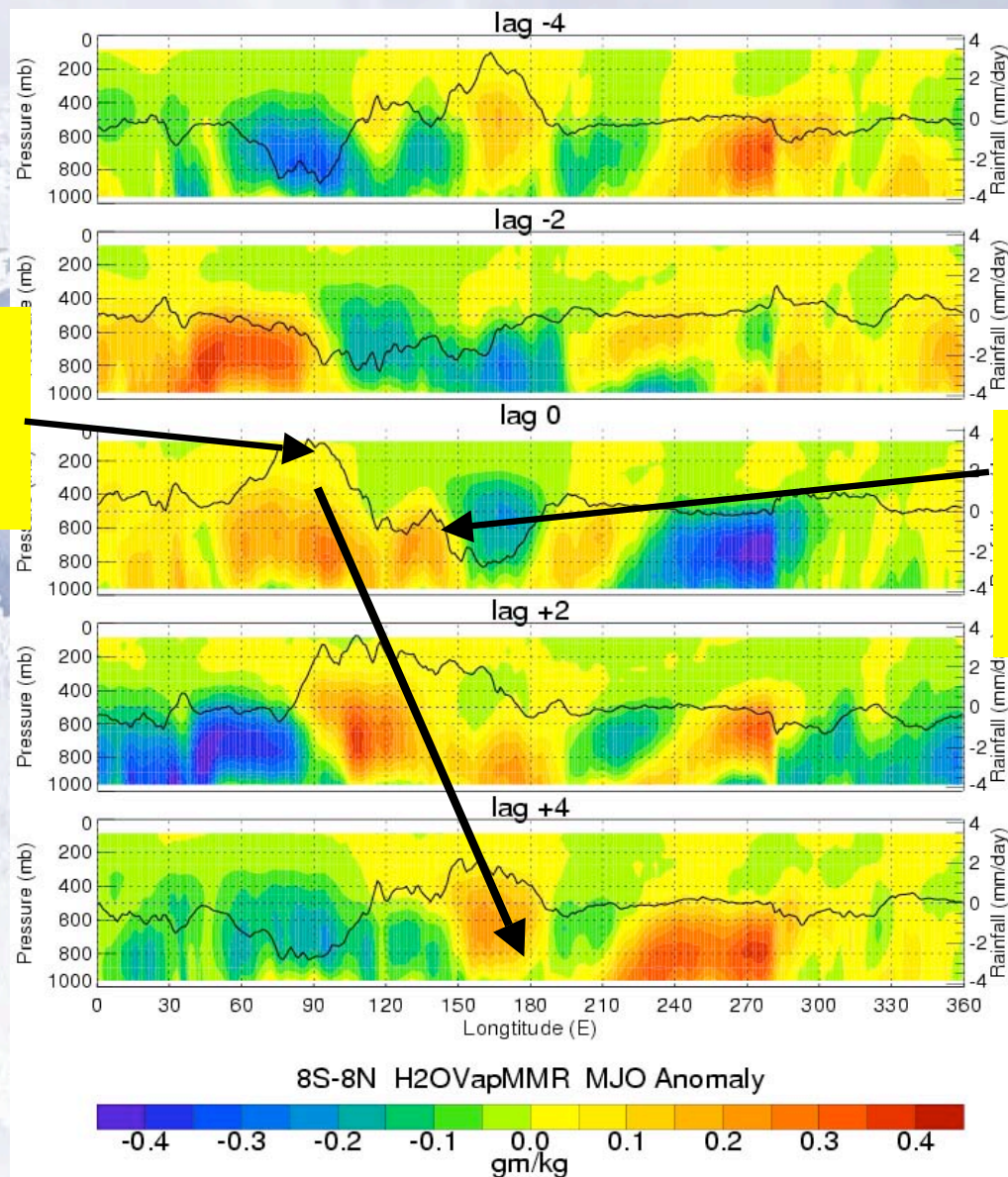
✠ A comprehensive theory for the MJO is still lacking.

*Madden & Julian [1971; 1972],
Lau and Waliser [2005], Zhang [2005]*



LARGE-SCALE ZONAL/VERTICAL MOIST STRUCTURE

**Equatorial enhanced
MJO convection as
indicated by positive
rainfall anomaly**



-20 Days

-10 Days

**Low-level
Moistening Leads
MJO Deep
Convection.**

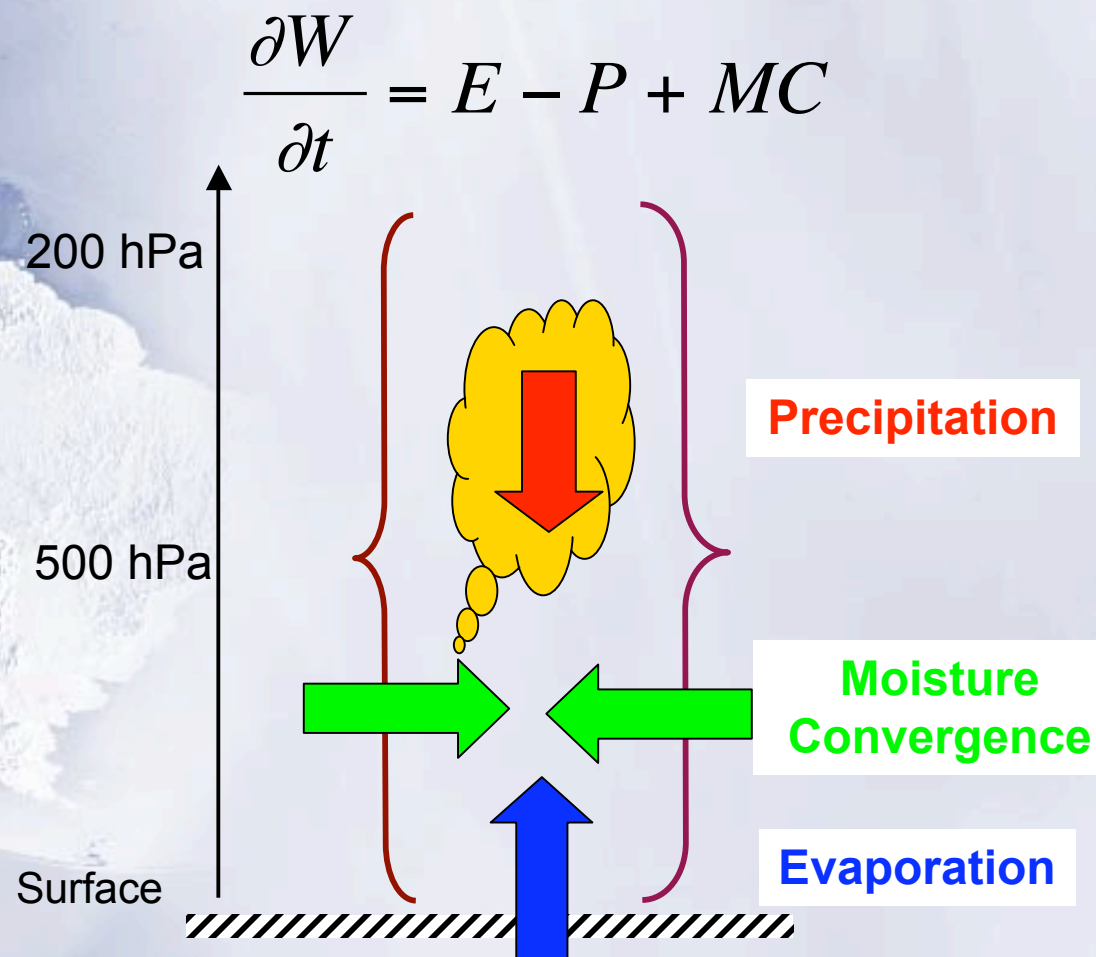
+10 Days

+20 Days

Tian, B. J., D. E. Waliser, Fetzer, Lambrigtsen, Yung, and Wang, 2006: Vertical moist thermodynamic structure and spatial-temporal evolution of the MJO in AIRS observations. *J. Atmos. Sci.*, **63, 2462-2485.**

QUESTION?

What Physical or Dynamical Mechanism is Responsible for the Low-level Moist Preconditioning of the MJO?



HYDROLOGICAL DATA

✧ AIRS H2OVapMMR & TotH2OVap

V4, L3, global, $1.0^\circ \times 1.0^\circ$, 2xdaily, 09/01/2002-04/30/2007. Chahine et al. (2006)

✧ TRMM 3B42 Rainfall:

40S-40N, $0.25^\circ \times 0.25^\circ$, 3-hourly, 01/01/1998-06/30/2007. Huffman et al. (2007)

✧ QuikSCAT & TMI Moisture Transport

40S-40N, $0.25^\circ \times 0.25^\circ$, 2xdaily, 08/1999-12/31/2005. Liu and Tang (2005)

✧ OAFlux Evaporation

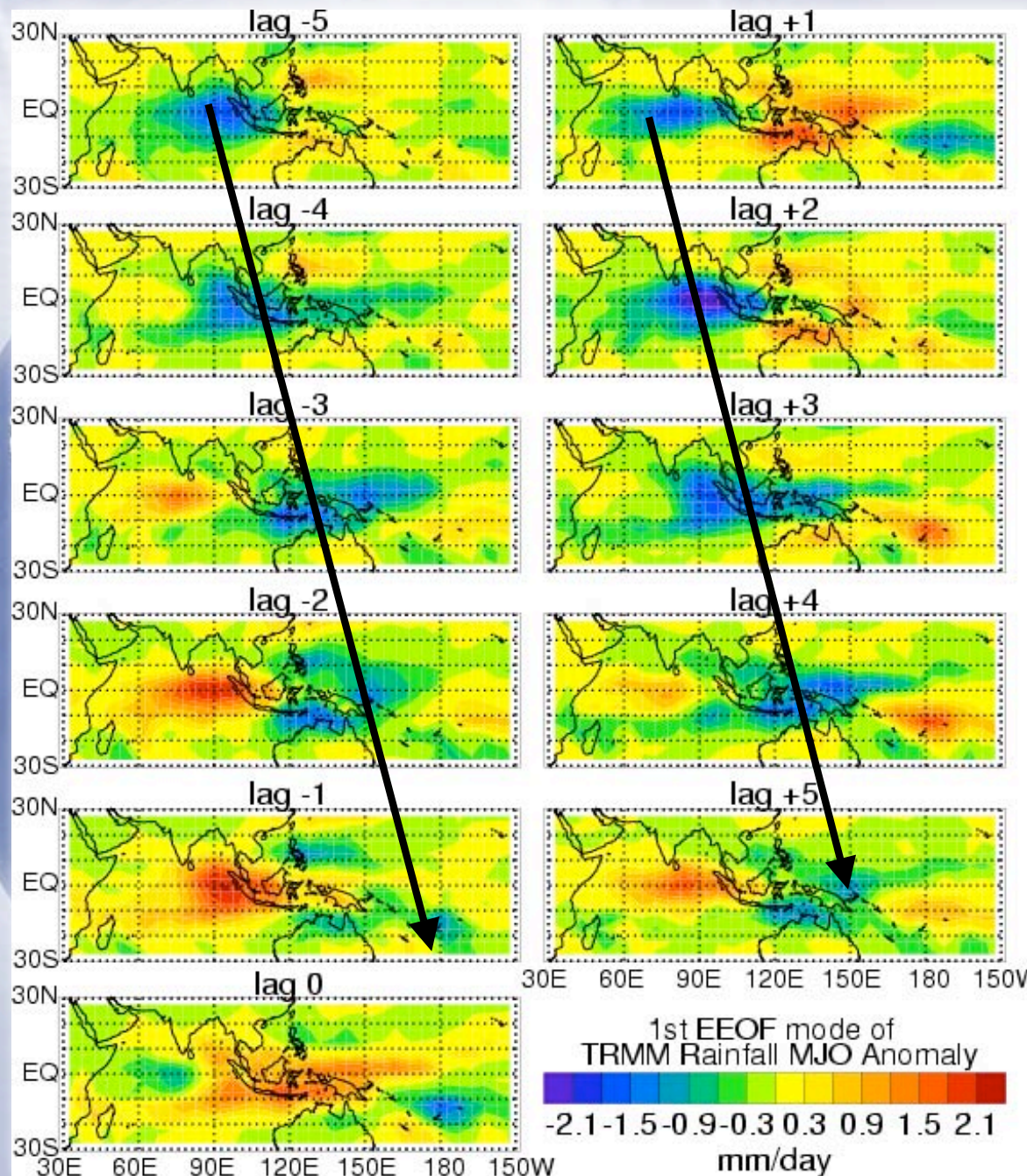
65S-65N, $1.0^\circ \times 1.0^\circ$, daily, 01/01/1981-12/31/2002. Yu and Weller (2007)

GENERAL ANALYSIS METHODOLOGY

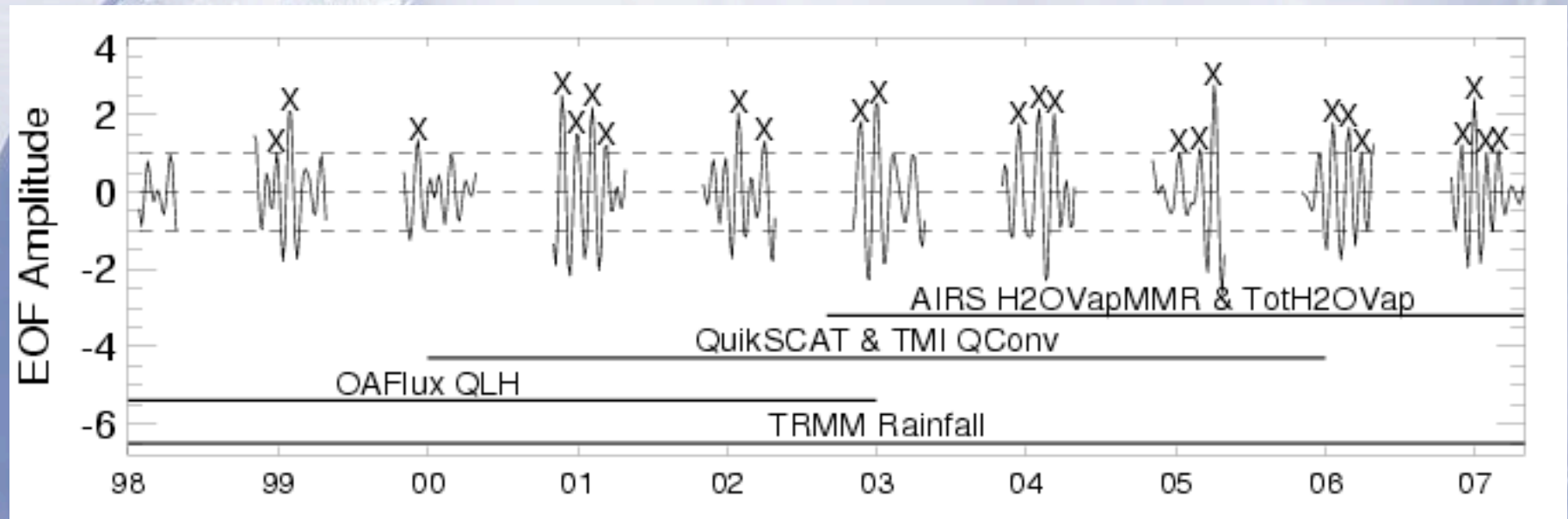
- (1) Perform an Extended EOF (EEOF) analysis on band-passed (30-90 day) rainfall data (e.g., TRMM).
- (2) Identify MJO events from EEOF amplitude time series.
- (3) Composite MJO events in band-passed rainfall and target quantities (e.g., moisture, evaporation and moisture convergence).

Tian et al. [2006; 2007; 2008]

SPATIAL-TEMPORAL PATTERN OF THE 1ST EEOF MODE OF RAINFALL MJO ANOMALY



AMPLITUDE TIME SERIES OF THE 1ST EEOF MODE OF RAINFALL MJO ANOMALY



The x indicates the dates (x) of selected MJO events.

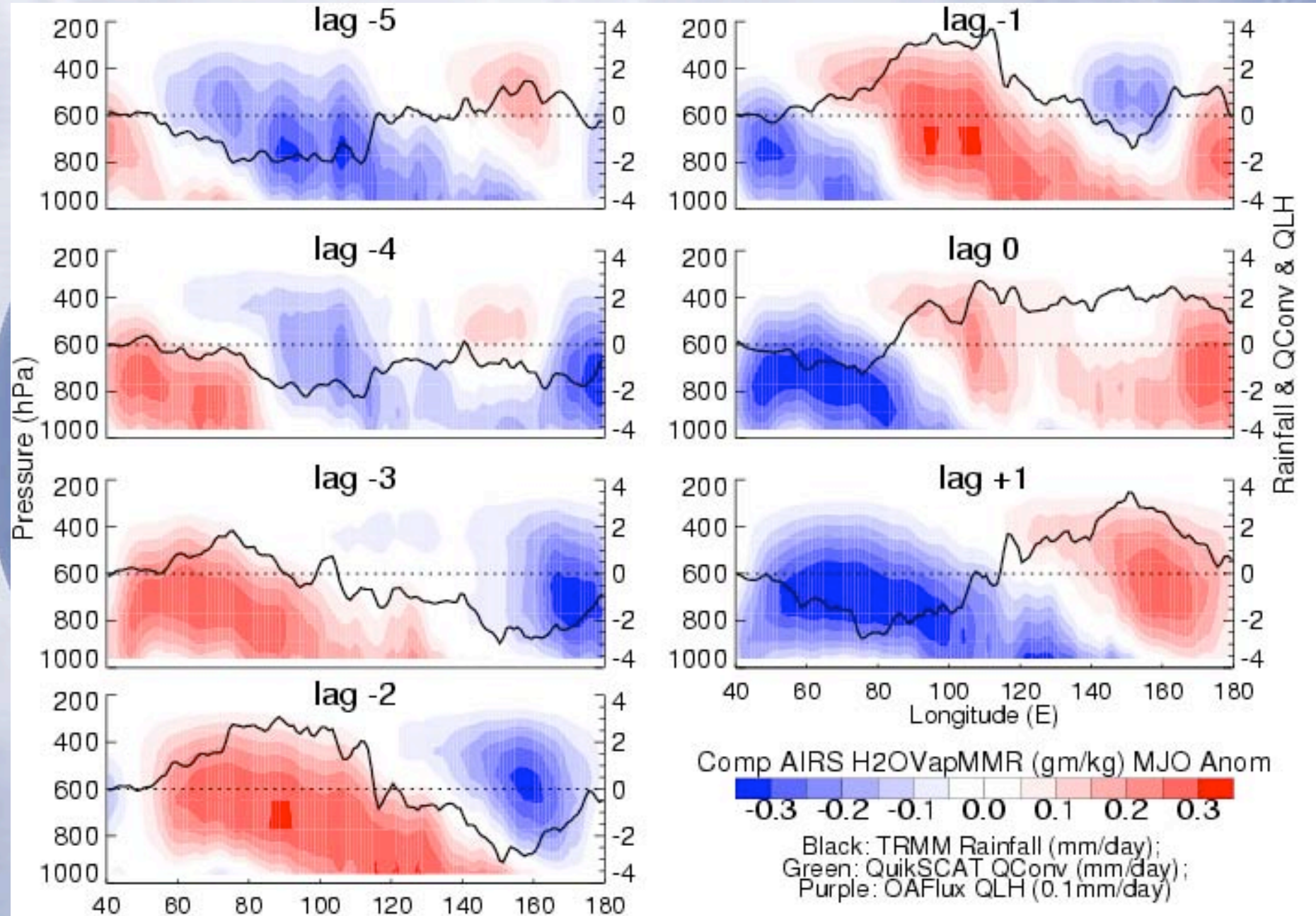
TRMM: 24

AIRS: 15

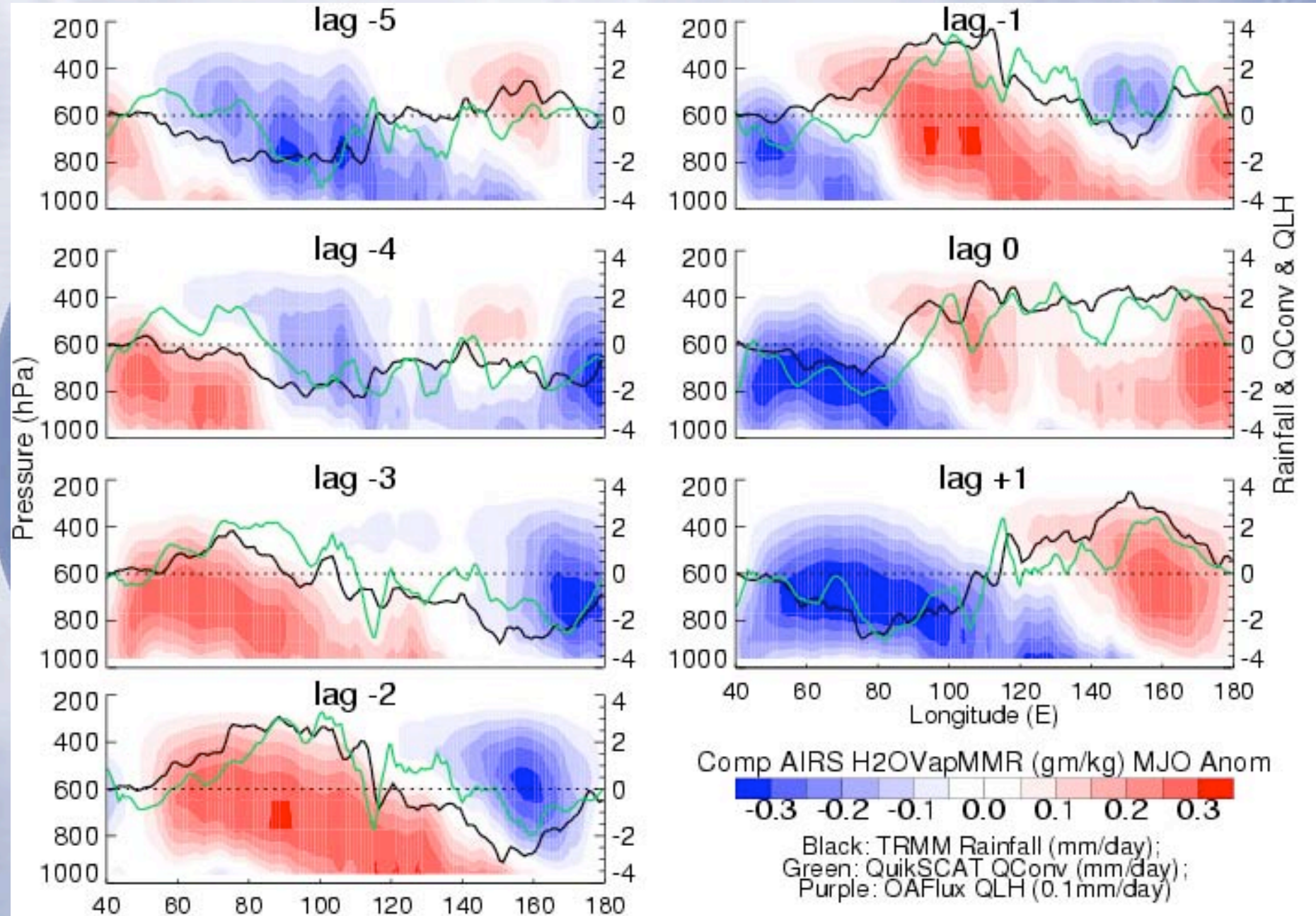
QuikSCAT&TMI: 14

OAFlux: 10

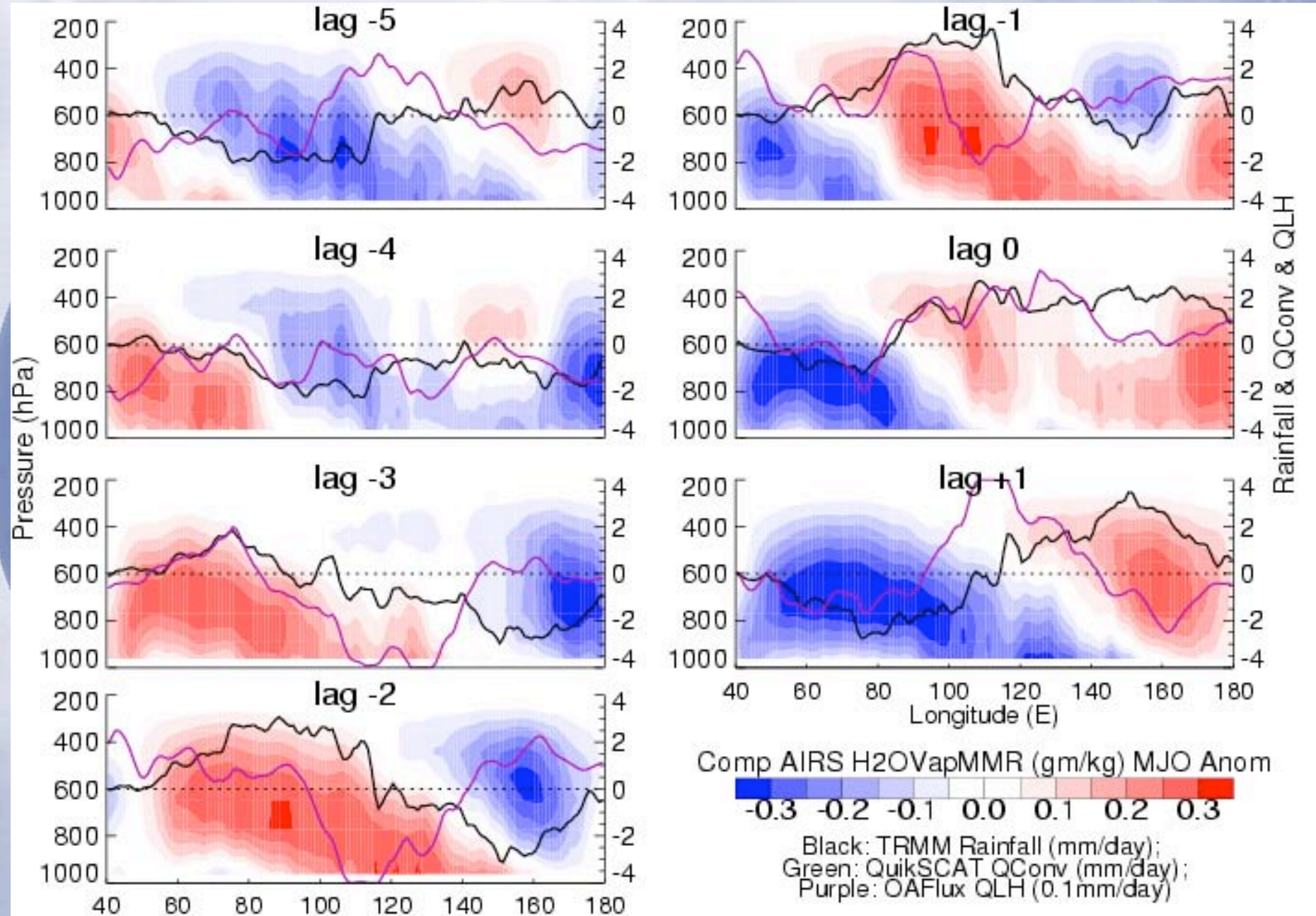
COMPOSITE MJO CYCLE



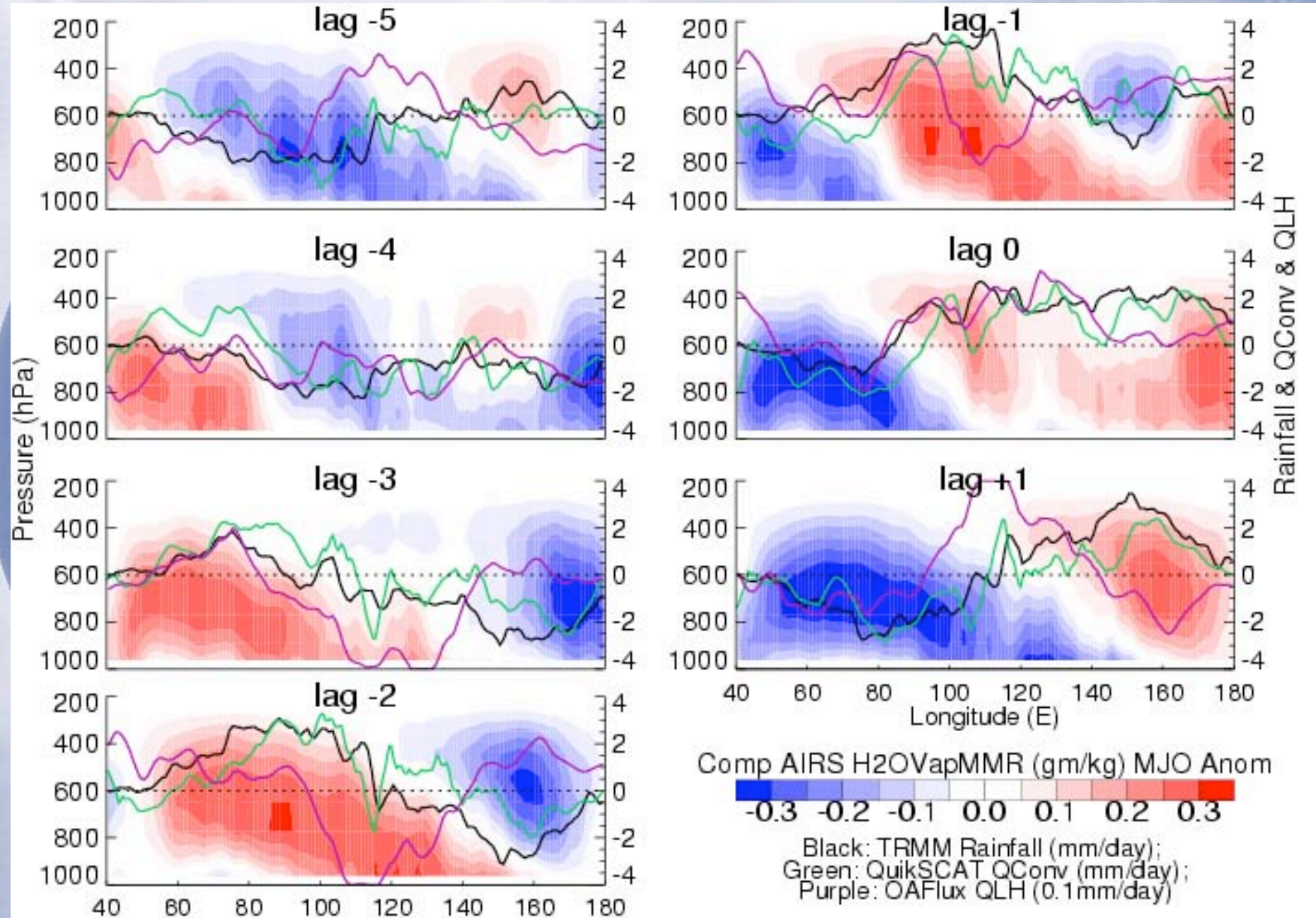
COMPOSITE MJO CYCLE



COMPOSITE MJO CYCLE



COMPOSITE MJO CYCLE

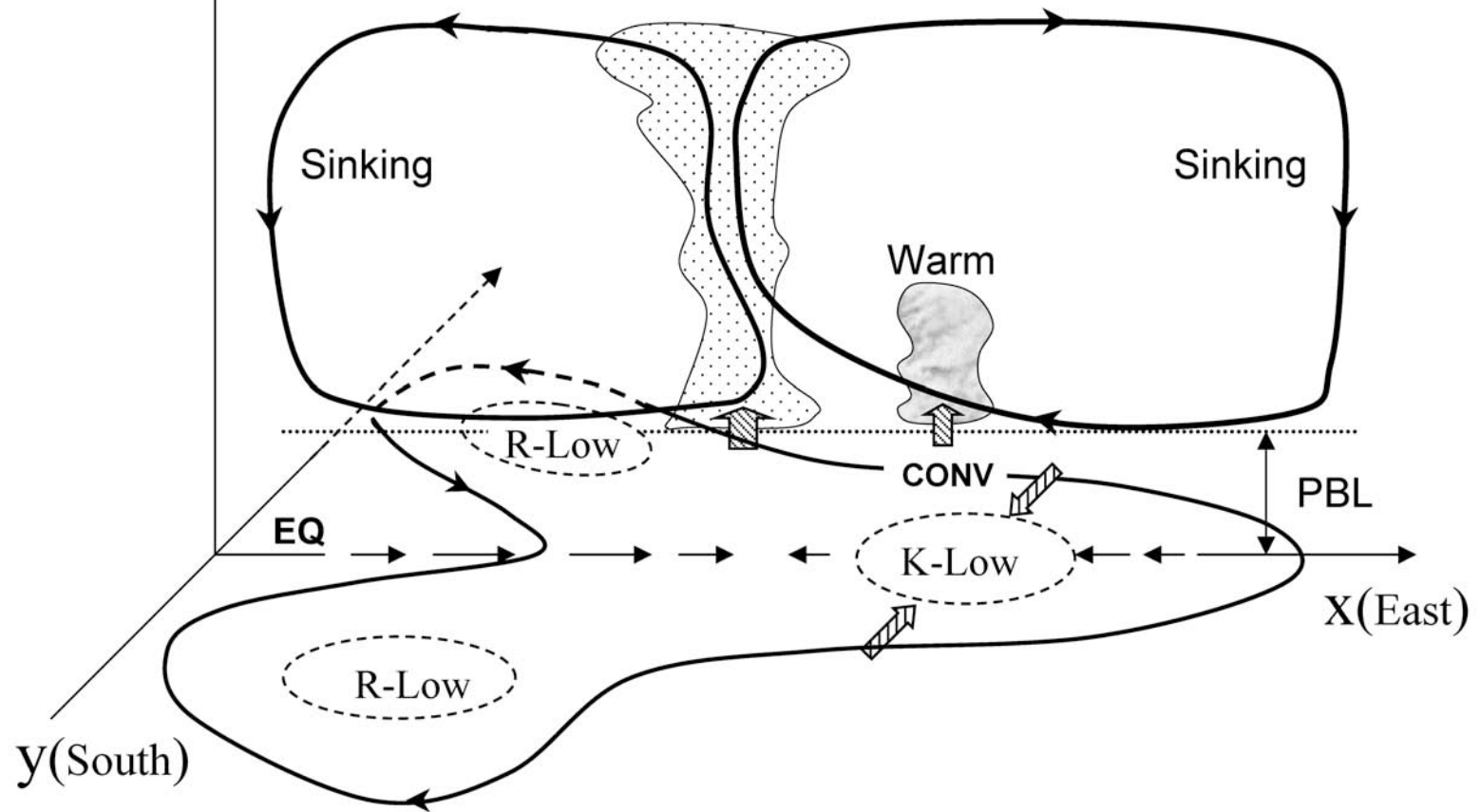


MJO PRECONDITIONING PHASE

- ☒ Large lower-troposphere moistening ($W > 0$);
- ☒ Small precipitation anomaly ($P \sim 0$);
- ☒ Enhanced moisture convergence ($C > 0$);
- ☒ Suppressed evaporation ($E < 0$);

THE LOW-LEVEL MOIST PRECONDITIONING IS DUE MAINLY TO THE ENHANCED (LOW-LEVEL) MOISTURE CONVERGENCE.

FRICTIONAL WAVE-CISK



**Schematic of the frictional wave-CISK model of the MJO
(Wang 1998, 2005; Salby et al. 1994)**

WIND-EVAPORATION FEEDBACK

Tropics - Mean Low-level Easterlies

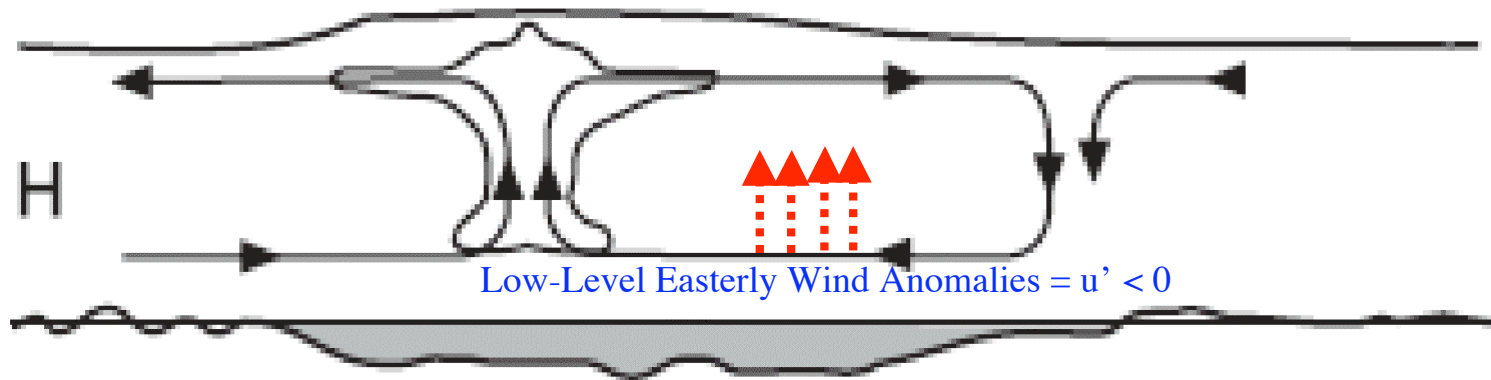


$\bar{U} < 0$

$u' < 0$ to east of convection

High wind speed \Rightarrow High Evaporation

Favorable conditions for eastward propagation

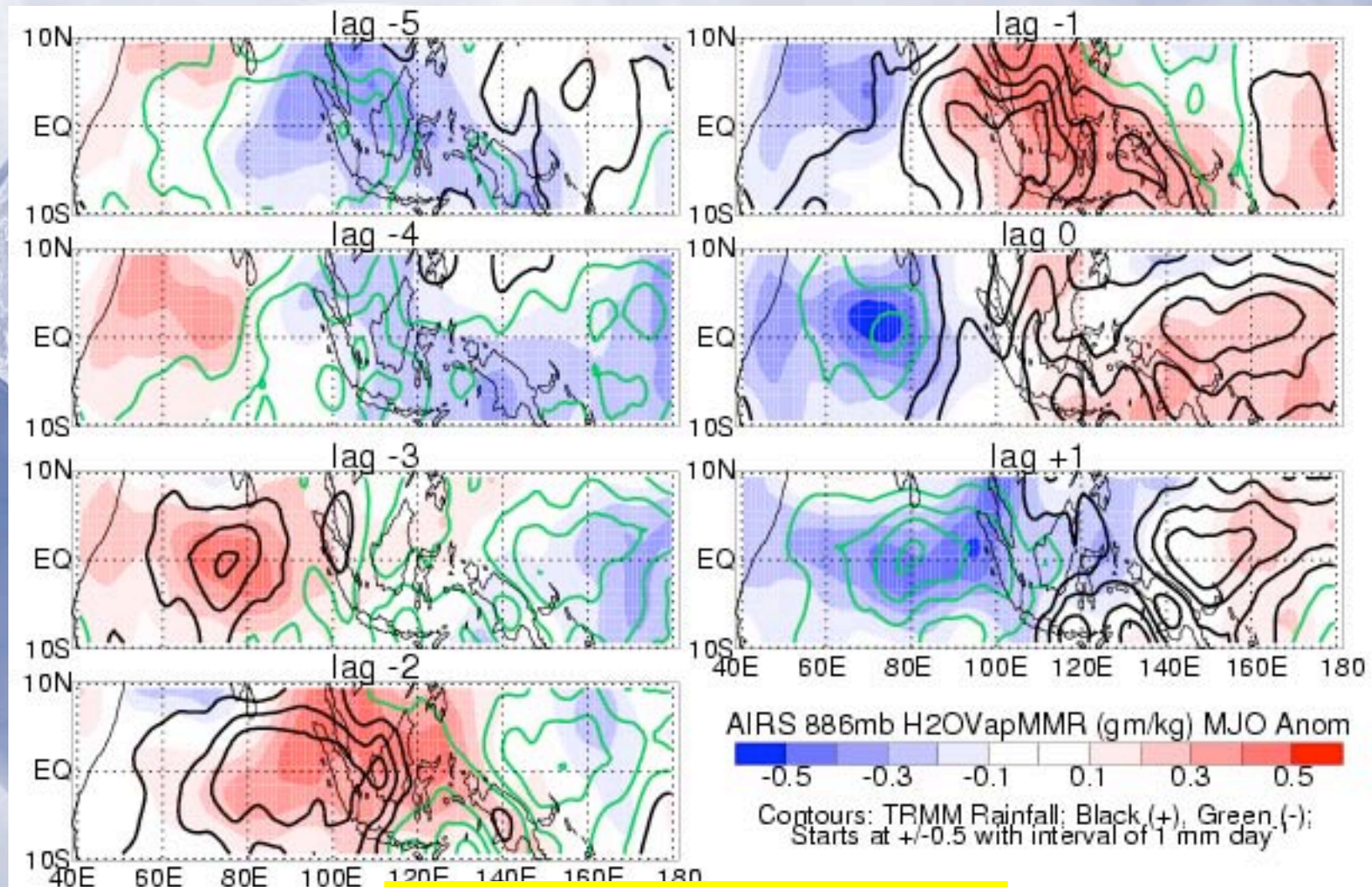


**Schematic of the wind-evaporation feedback model of the MJO
(Emanuel 1987; Neelin et al. 1987)**

SUMMARY

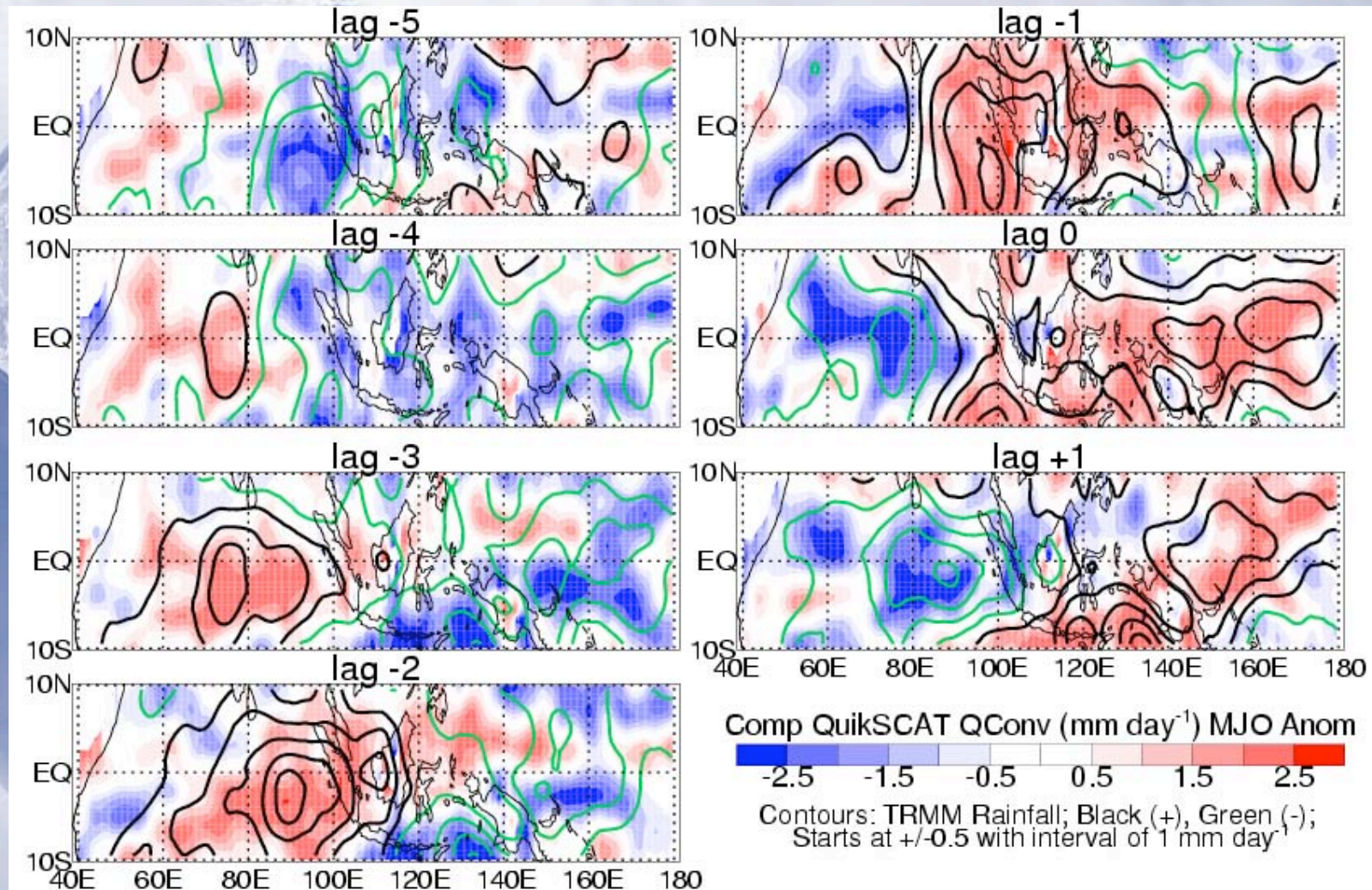
- ✦ **AIRS observation indicates that low-level moist anomaly leads the MJO deep convection and precipitation.**
- ✦ **QuikSCAT & TMI moisture transport and OAFlux evaporation observations indicate that the low-level moist preconditioning of the MJO is due mainly to the low-level moisture convergence instead of the surface evaporation.**
- ✦ **The satellite observations support the frictional wave-CISK theory instead of the wind-evaporation feedback theory of the MJO.**

PRECIP & LOW-LEVEL MOISTURE ANOMALIES



Near-equatorial low-level moisture anomalies tend to lead rainfall anomalies

PRECIP & MOIST CONV ANOMALIES



Near-equatorial total column (low-level) moisture convergence anomalies tend to lead rainfall anomalies

PRECIP & EVAP ANOMALIES

